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Reconstructing Students' Misconceptions on Work and Energy through the PDEODE*E Tasks with Think-Pair-Share

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ABSTRACT
This study aimed to expand PDEODE*E Tasks with the Think-Pair-Share model for reconstructing students' misconceptions on work and energy. The PDEODE*E Tasks with Think-Pair-Share model implemented for students who had not taught the concept of work and energy. The participants include 36 students of tenth grade (22 girls and 14 boys, whose ages ranged from 15 to 16 years) at a senior high school in Bandung, Indonesia. Students' misconceptions evaluated by administering an Energy and Momentum Conceptual Survey (EMCS) comprised of 18 items in the form of four-tier, as pre- and post-test. Furthermore, students' thoughts also elicited using worksheets of seven PDEODE*E tasks. A qualitative approach is used to analyze the test and worksheets. The data analysis had mostly focused on work and energy concepts such as work, energy, and conservation of energy. The findings suggested that PDEODE*E Tasks with Think-Pair-Share model improved students' conceptual understanding and reduced most of their misconceptions despite a little misconception motionless occurred. Teachers can use PDEODE*E tasks with the Think-Pair-Share model to reconstruct students' misconceptions.

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Introduction

According to the constructivist theory, it is only through their own construction of knowledge that students come to understand various concepts (e.g. Bachtold, 2013; Chrzanowski et al., 2018; Fratiwi, Samsudin, Ramalis, & Costu, 2020; Khanna, Mello, & Revzen, 2012; Kiryak & Calik, 2018). It seems reasonable then misconceptions can be overcome only by students reconstructing their own knowledge (e. g. Aksit & Wieber, 2020; Fratiwi et al., 2019; Kaniawati et al., 2019; Lin, Hsu & Yeh, 2012). Students have conceptions that explain some of the mathematical and scientific phenomena, but these conceptions are different from the currently accepted disciplinary concepts presented in instruction. As students' concepts regularly are different from instructed concepts and show students' reasoning, education in physics and science must take them seriously (Alanazi, 2020). Misconceptions are so common, learning physics and science must engage a shift away from misconceptions to expert concepts. This shift is often characterized as a replacement. An adequate expert idea must be developed and replace existing misconceptions. Learning involves both the acquisition of expert concepts and the dispelling of misconceptions. The statement that removing misconceptions has no negative consequences because they play no productive role in expertise understood in the substitute view. Misconceptions occur from students' prior learning (Osman, Boujaoude, & Hamdan, 2017; Topalsan & Bayram, 2019; Suhandi, et al., 2020), either in the classroom (especially for physics) or from their interaction with the physical and social world.

In Newtonian mechanics, perhaps, the domain most extensively analyzed-researchers have agreed that students' misconceptions about force and motion are the result of day-to-day experiences in the physical world (e.g. Ayar, Aydeniz, & Yalvac, 2015; Zajkov, Gegovska-Zajkova, Mitrevski, 2017). Students have common misconceptions on the work and energy concepts. The concepts of energy are to do with living and moving things, energy makes things work and energy changes from one form into another (Gilbert & Watts, 2013; Hanson & Seheri-Jele, 2018; Samsudin et al., 2021). An example of the concept work can be more easily used to know the state of motion of an object due to outside influences (Force). When a Force $\overrightarrow{(F)}$ is applied to an object then it covers a displacement's in direction on the force applied. It is said that the work has been done on an object. The work represented by W (work) and to a constant force formulated as

$$W = \vec{F}.\vec{s} = \vec{F}.\vec{s}\cos\theta \quad (1)$$

Equation (1) shows that the concept of work dependent on the angle between the vector Force and vector displacement s. If the Force is not constant, it must be added to each piece transitions to the Force constant,

$$W = \sum \vec{F_i}.\Delta\vec{s_i} \quad (2)$$

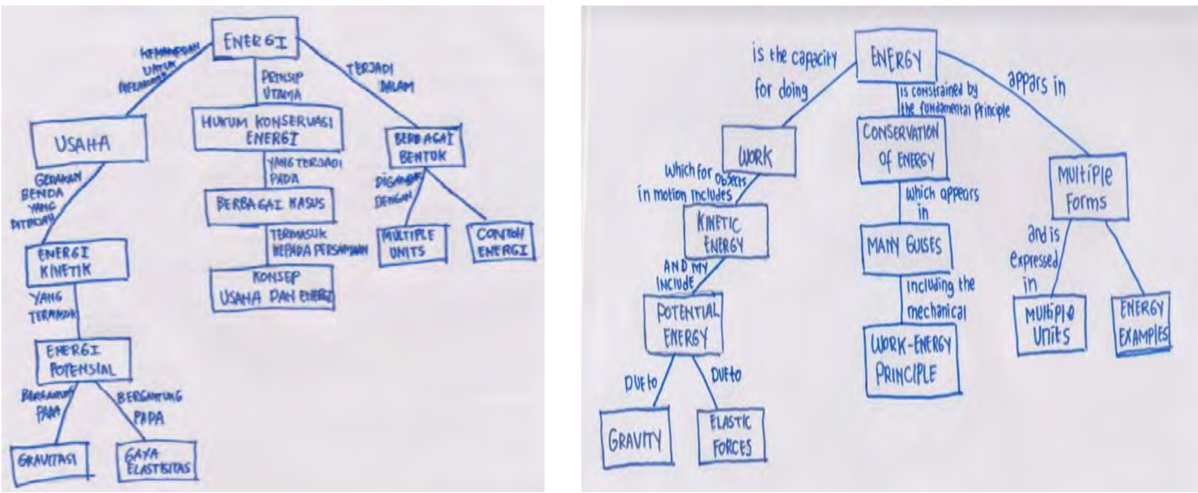
When the changes are continuous, the formulation above is transformed into an integral

$$W = \int_a^b \vec{F}.d\vec{s} \quad (3)$$

The unit of work done Joules or J, $\vec{F}$ is the constant force applied in Newton, $\vec{s}$ is the displacement covered by the body in the direction of the force in a meter. When the force and the displacement covered are not in the same direction then we use the component of force along the direction of the force. The framework of work and energy could be analyzed from the concept map, those follow:

Figure 1

(a) Original Version of Concept Map about Work and Energy; (b) Translated Version of Concept map about the framework of work and energy concept



(a) (b)

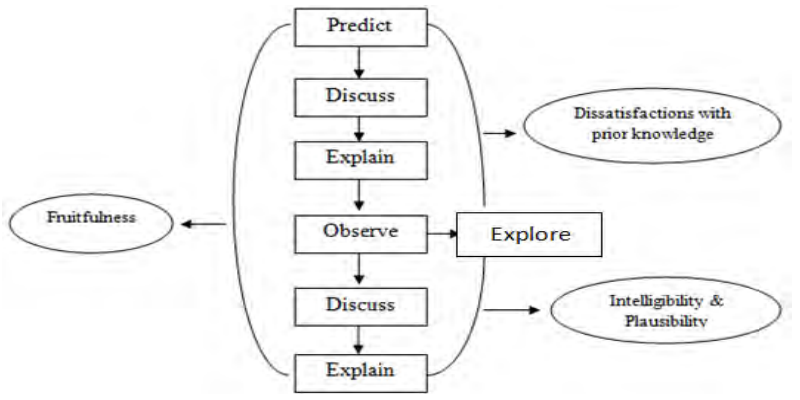
Alternative solutions can answer how to overcome misconceptions by using the appropriate learning model or learning strategy through providing conceptual understanding for students. A teaching strategy should be developed for teachers to provide students to make the connection between their knowledge of science and related everyday situations (e.g. Caleon, Tan, & Cho, 2018; Cepni, Ulger, & Ormanci, 2017; Henke & Hottecke, 2015; Topalsan & Bayram, 2019; Ulum, et al., 2020; Basori et al., 2020), such as Predict, Discuss, Explain, Observe, Discuss, and Explain (PDEODE) teaching strategy.

The PDEODE strategy initially is suggested by Kolari, Viskari, & Ranne (2005) in engineering education. This is an important teaching strategy that supports discussion and a variety of views. Therefore, this strategy is intended to be used as a medium in helping students make sense of everyday situations. The PDEODE teaching strategy used here consists of six steps. In the first step (P: Prediction), the teacher presents a phenomenon about the topic to students to predict the outcome of the phenomenon individually and to explain their prediction. In the second step (D: Discuss), students are asked to discuss in groups to share their ideas in their own group and to think about it together. In the third step (E: Explain), students in each group are asked to arrive at a mutual solution to the phenomenon and to give their results to other groups through whole-class discussions. Afterward, the students work in groups to perform the hands-on experiment and they individually explain the issue based on the evidence from their observations of the hands-on experiments. In this step (O: Observe), the students observe changes in the phenomenon and the teacher should guide them to make observations that are relevant to target concepts. In the fifth step (D: Discuss), the students are asked to settle their predictions with their actual observations they made in the early step. Here the students are asked to analyze, compare, contrast, and criticize their classmates in the groups. In the last step (E: Explain), the students confront all discrepancies between observations and predictions (e.g. Costu, 2008; Costu, Ayas, & Niaz, 2012, Samsudin et al., 2019). The present study tries to assess the effectiveness of the PDEODE teaching strategy on the amount to which students recognize scientific concepts and use them for interpreting the phenomena in their everyday life.

Based on previous research on the PDEODE teaching strategy, researchers conducted a more detailed study and found an excuse as the novelty for continued development. The continued development resulted in: Predict, Discuss, Explain, Observe, Discuss, Explore, and Explain (PDEODE*E). The PDEODE*E is an innovation in science education to reduce misconceptions education students in college-level physics. The PDEODE worksheet was approved in two formats: student worksheets and exploration sheets. In the exploration sheet, there is a slot for physics student teachers to additional behavior exploration of the initial observations that have been made in the worksheet. The exploration sheet is a step development of an available worksheet (Samsudin, Suhandi, Rusdiana, & Kaniawati, 2015).

Figure 2

*The relationship between PDEODE*E teaching strategy and conceptual change model*



Adding E* into the PDEODE, we aimed to remove a few disadvantages and to empower of the PDEODE teaching model (Samsudin et al., 2015). The PDEODE cannot facilitate the students to explore the concept deeper and more comprehensive way. Also, PDEODE is not able to analyze, synthesize, and infer relationships between concepts, both qualitatively and quantitatively without the exploration phase (E* phase). We state that the PDEODE*E based teaching model was more significant to promote conceptual change (e.g. Samsudin et al., 2017; Fratiwi, Samsudin, & Costu, 2018). Correspondingly, we utilized exploration sheet individually to explore magnetic concepts to change students' misconceptions towards scientific conceptions properly (Samsudin et al., 2015 & 2017).

In the previous research, another way to reduce misconceptions was using the Think-Pair-Share model (Eymur & Geban, 2017). The Think-Pair-Share (T-P-S) model intended to encourage students to share and discuss ideas around a topic, issue, or problem (Chen & Chiu, 2016). Students can plan to use Think-Pair-Share within a designed lecture, but it is also easy to apply it impulsively. Generally, the teacher asks a question, the students create about the issue (think), then pair up to consider their solutions (pair), and then offer their solutions to the complete course (share) (Cooper, 2018). This model can be used to gauge conceptual understanding, filter information, illustrate conclusions, and give confidence in peer learning among students. Results can also sign to you that you may need to re-explain content or give further support for students. It allows students to discuss with each other of the meaning of concepts or their planned solutions of the issue. The model provides a diagnostic point to make sure students are on the path. So, students can reconstruct their own problems encountered with the guidance of teachers as well as give opportunities to students to get used to finding and solving problems reasonably, systematic, and directed to a conclusion.

TPS type cooperative learning can give students more time to think, respond, and help each other (Ebrahim, 2012). The cooperative learning type of TPS makes students swap ideas with each other before putting it to more groups big. Think-Pair-Share as described initially in the cooperative learning literature, a Think-Pair-Share train often begins with information that provided initially been through a reading assignment, a short lecture, a videotape, etc. The instructor then poses a single question and students are instructed to think reflect on the question and to note their response in writing. Students then turn to a partner and share their responses. This can end the sharing, or the pair might turn to another pair and share it again in groups of four. Think-Pair-Share is a collaborative learning model that (1) is efficient in very large classes, (2) encourages students to be reflective about course content, (3) allows students to confidentially formulate their thoughts before sharing them with others, and (4) can promote higher-order thinking skills.

The combination of PDEODE*E tasks and the TPS model has the potential to reconstruct students' misconceptions. The following is a framework of constructivist teaching sequence through PDEODE*E tasks and Think-Pair-Share model.

Figure 3

*The constructivist teaching sequence with the PDEODE*E Tasks and Think-Pair-Share*

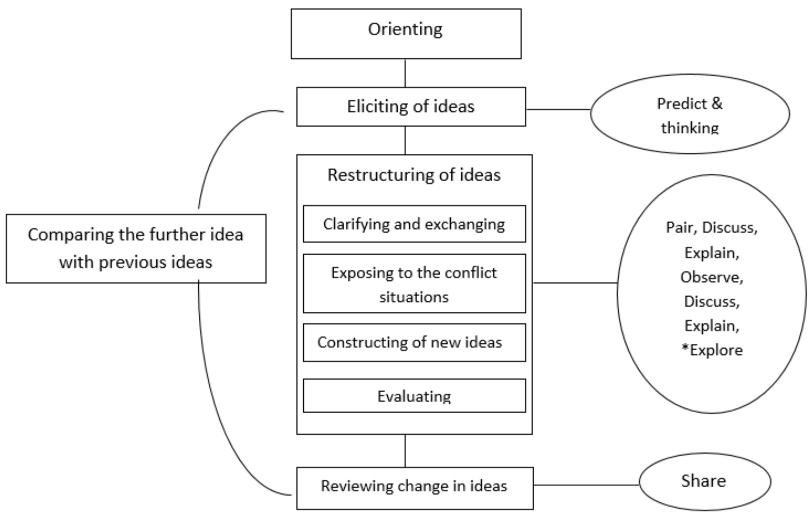


Figure 3 shows that the framework of the constructivist teaching sequence with the PDEODE*E task and Think-Pair-Share. The learning sequence of this strategy is a powerful way to overcome the learning problems of students' misconceptions about work and energy. The sequences have already been described from orienting, eliciting, and restructuring (clarifying, exposing, constructing, evaluating) and finally reviewing all the ideas. All steps of the learning strategy have a high correlation with PDEODE*E tasks. For instance, in exposing to conflict situations is equal to the step of Predict (P). The students who involve in the conflict situation hold several misconceptions because they are confused with their pre-conceptions.

Thus, the purpose of this study was to reconstruct the students' conceptions from the misconceptions condition to scientific conceptions of work and energy through the PDEODE*E tasks with the Think-Pair-Share model. In terms of achieving the research goal, we have already arranged several research questions, that are, 1) identifying students' conception on work and energy; 2) analyzing the change of students' misconceptions on work and energy after implemented PDEODE*E tasks with Think-Pair-Share model.

Methods

Participants

Participants in this study include 36 students of tenth grade (22 girls and 14 boys, whose ages were ranged from 15 to 16 years) at a senior high school in Bandung, Indonesia. The students in this study had not been trained in the concept of work and energy. The participants were purposefully selected from a class and they voluntarily participated in the study. All students took to the pre- and post-test. There were three teaching-learning meetings and they have been conducted for 135 minutes. The PDEODE*E tasks with the Think-Pair-Share model have been already utilized in this study will be described in the next section.

The Test Items of Work and Energy Instrument

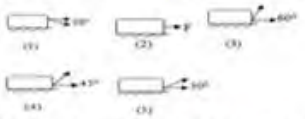
To measure students' misconceptions about work and energy before and after teaching the PDEODE*E tasks with Think-Pair-Share, the instruments consist of 18 test items were utilized by using a quantitative approach. The authors have developed and published the test items of the instrument at the international journal (Singh & Rosengrant, 2003). The instrument was called Energy and Momentum Conceptual Survey (EMCS). The test items were planned in the form of four-tier test items. Figure 4 shows an example of test items on work and energy.

As can be seen from Figure 4, the EMCS is separated into four tiers. The first tier is in the format of multiple choices, the second tier is in the second-tier levels of confidence in the form of answers tier-1, tier-3 related reasons in the form of answers tier-1, and tier-4 form the levels of confidence in reason tier 3 for instants: "sure" and "not sure" (as agreed in the several kinds of literatures Caleon & Subramaniam, 2010; Kaniawati, et al., 2019; Peşman & Eryılmaz, 2010; Samsudin, et al., 2020). The design of the test instrument that includes the fourth tier used by researchers in the development of diagnostic test instruments in the form of students' conceptions level format EMCS four-tier test. The EMCS was validated by a section comprising of three physics educators as validators. The final form of the test was administered to the sample 4 weeks before (pre-test) and after the teaching (post-test). It is understood that period between application of the same test as pre- and post-tests is enough for students not to remember the items.

Figure 4

An EMCS instrument test item on work and energy concept

1.1 Objects with mass *m* are drawn in *F* force as shown in the following figure:



If the displacement of an object is the same, then the force that produces the largest work is shown in the figure number.....

a. (1)
b. (2)
c. (3)
d. (4)
e. (5)

1.2 Level of confidence in answer choice number 1 .1:

a. Sure
b. Not Sure

1.3 Your reason for the choice of answer on question 1 .1:

a. If the force elevation angle to the displacement has a large value then the resulting business value is large.
b. Work is not influenced by the elevation angle of the force to the displacement so that the business generated under all conditions is the same.
c. Work was generated by a style that direction in the direction of movement is negative.
d. Effort generated by forces that are in directional direction with positive value movements.
e. ....

1.4 Level of confidence in answer choice number 1 .3

a. Sure
b. Not Sure

We also analyzed each test item (ten test items in the EMCS) in terms of learning indicators and Anderson & Krathwohl (2001)'s Taxonomy, which is detailed in Table 1.

Table 1

EMCS test instrument specification on work and energy concept

Number Questions	Learning Indicators (LI)	Anderson's Cognitive Aspects*		
		C2	C3	C4
1	Choosing the correct statement about non-conservative Force		√	
2	Sorting the value of the motion of the object is influenced by the elevation angle of the force against displacement		√	
3 4	Determining the relationship of the direction of force and direction of motion of an object (displacement) to work value		√	
5 6	Comparing the value of the object's velocity at the same height as two different trajectories or mass of objects	√		√
7	Determining the kinetic energy value of moving objects vertically up and down		√	
8	Proving the law of conservation of mechanical energy in a conservative force	√		
9	Showing the largest work based on the elevation angle of force against displacement	√		
10	Illustrating a graph of kinetic energy relation with altitude for uprooted objects			√

Number Questions	Learning Indicators (LI)	Anderson's Cognitive Aspects*		
		C2	C3	C4
11	Describing the relationship between potential energy, kinetic energy, and mechanical energy			√
12	Selecting a work relationship graph based on the direction of the force vector to the displacement			√
13	Choosing a graph of potential energy related to time			√
14	Showing the mechanical energy relations with the work of conservative	√		
15	Choosing the right statement about work concept			√
16	Linking the law of conservation of mechanical energy to satellite motion		√	
17	Choosing the correct statement of energy in free-fall motion	√		

Note. C2, C3, and C4 stand for understanding, applying, and analyzing on Anderson et al.'s Taxonomy (1999)

The PDEODE*E Tasks with Think-Pair-Share model

The PDEODE*E task with Think-Pair-Share model about work and energy concepts was used in teaching. PDEODE*E tasks were administered to the sample in groups (total of eight groups: four students in each group). At the beginning of each teaching activity, the activity page on which students would write down their explanations was handed out to each group. Students worked collaboratively in groups and they packed in each activity sheet individually. These sheets were collected at the end. In the middle of reconstructing the learning strategies, researchers have already determined to use the PDEODE*E tasks with the Think-Pair-Share model, based on our perceptions of its significance for the educational perspectives in the PDEODE*E Tasks with the Think-Pair-Share model this research detailed in Table 2.

Table 2

*Teaching activities in the PDEODE*E tasks with the Think-Pair-Share model*

PDEODE*E Task		Context
Task I	Part I	• Definition of work in physics with work in everyday life. (*Orientation*) • The condition of a force is said to do work on an object. (*Think*) • Factors affecting work value. (Think -*Pair*) • Concept positive work and negative work. (*Share*)
	Part II	• Equality of work. (*Evaluation*)
Task II	Part I	• Definition of the energy concept. (*Orientation*) • Factors affecting energy value. (*Think*) • Equality of potential energy and kinetic energy. (Think-*Pair*) • The relationship between work with potential energy and kinetic energy in everyday life. (*Share and evaluation*)
Task III	Part I	• The equation of law of conservation of mechanical energy. (*Orientation*) • The concept of conservative force and non-conservative force. (Think-*Pair*) • Verify the law of conservation of mechanical energy in a conservative and non-conservative force. (*Share and evaluation*)

Before the PDEODE*E task with the Think-Pair-Share model, the EMCS instrument was given to students to get their attention to the center knowledge of the activities. Afterward, implementation of the tasks, the EMCS was then re-given to participants if they demonstrated an understanding of the concept. At the creation of each teaching activity, the PDEODE*E tasks and the Exploration sheet were handed out to both students. Students worked collaboratively in each group, and they packed in their worksheet separately. The first author gave the instruction; therefore, we unspoken that she skillfully occupied in the PDEODE*E task with the Think-Pair-Share model. She was able to interrelate with the groups' members, particularly discussions part in the PDEODE*E tasks. In other words, the discussions' part was guided by the lecturer correctly. In the second discussion (D) and exploring part (E*), the lecturer visited the eight groups, requested some follow-up questions, and gave some suggestions to lead students.

Data Analysis

The diagnostic-test items have been analyzed under the following categories and headings in Table 3, which were suggested by (Samsudin, et al., 2017).

Table 3

Criteria for analyzing the four-tier test items in EMCS

Criterion	Students' responses for the first tier*	Levels of Confidence	Students' responses to the third tier	Confidences Rating
Misconceptions (M)	F	Sure	F	Sure
No Understanding (NU)	F	Sure	F	Not Sure
	F	Not Sure	F	Sure
	F	Not Sure	F	Not Sure
Understanding (U)	T	Sure	T	Sure
Partial Understanding (PU)	T	Sure	T	Not Sure
	T	Not Sure	T	Sure
	T	Not Sure	T	Not Sure
	T	Sure	F	Sure
	T	Sure	F	Not Sure
	T	Not Sure	F	Sure
	T	Not Sure	F	Not Sure
	F	Sure	T	Sure
	F	Sure	T	Not Sure
	F	Not Sure	T	Sure
	F	Not Sure	T	Not Sure
Encodable (EC)	Respondent do not fulfill (response) all or part of tiers in instrument test items			

Note. F and T stand for False and True

As can be seen in Table 3, students' responses were examined thematically and the following criterion was used: Understanding (U), Partial Understanding (PU), Misconceptions (M), No Understanding (NU), and Encodable (EC). Students' conceptions and misconceptions were elicited from four-tier test items. We also presented reconstructing of students' misconceptions to see conceptual before and after the PDEODE*E Tasks with the Think-Pair-Share model. Using the changes, we also identified different schema for reconstructing students' understanding or misconceptions. To attend to inter-rater reliability issues, the incidence's analysis was completed on the scores of subsets examining the differences between the scores given by the researchers to the drawings. The instrument's reliability is 0.82 and the validity was determined via review of drawings by authors is 0.84.

Result and Discussions

Table 4 shows the results of students' conceptions of work and energy. All the students (from S1 to S36) presented for the pre- or post-test, they were completely extracted from the analyzing procedure.

While it can be seen from Table 4, most of the changes were positive conduct. For example, several of the students' responses were classified in the understanding (U) and partial understanding (PU) category increased after learning the PDEODE*E Tasks with the Think-Pair-Share model. Likewise, Table 4 presents mostly positive conceptual changes, a few of the students' responses were confidential into the misconceptions (M) category decreased after learning the PDEODE*E Tasks with the Think-Pair-Share model. This means that the students changed their misconceptions towards scientific conceptions. On the other hand, only a handful of students (e.g. S1, S5, and S8), did not change their misconception condition. This means that learning the PDEODE*E Tasks with the Think-Pair-Share model was incompetent to change all students' conceptions. The most important reason for this matter should be that researchers had a restriction problem related to control and to switch whole psychological problems or incorrect students' schema (i.e. students' thinking, engagement in collaboratively grouped work, and students' motivations). As a result, a few students could not change their misconceptions toward scientific conceptions. The related result could be seen in the conceptual change studies (e.g. Costu, Ayas, & Niaz, 2012; Samsudin, et al., 2016).

Table 4

Students' responses in each criterion and their changes from pre-test to post-test

No.	Understanding (U)		Partial Understanding (PU)		Misconceptions (M)		No Understanding (NU)		Encodable (EC)	
	Pre-test (f)	Post-test (f)	Pre-test (f)	Post-test (f)	Pre-test (f)	Post-test (f)	Pre-test (f)	Post-test (f)	Pre-test (f)	Post-test (f)
1.	0	S2,S3,S4,S7,S8, S9,S14,S17,S18, S19,S21,S26,S27,S28,S36 (15 students)	S7,S10,S11,S13, S14,S16,S22,S28,S29,S32,S33,S34 (12 students)	S1,S5,S6,S10,S11, S12,S13,S15,S16, S20,S22,S23,S24, S25,S31 (15 students)	S1,S2,S3,S4,S5, S6,S12,S18,S23, S26 (10 students)	S32 (1 students)	S8,S9,S15,S17,S19,S20,S21,S24, S25,S27,S35,S36 (12 students)	S29,S30,S33,S34,S35 (5 students)	S30,S31 (2 students)	0
2.	S10 (1 student)	S1,S4,S5,S14,S15,S16,S17, S18,S21,S22,S36 (11 students)	S5,S6,S9,S16 (4 students)	S6,S8,S9,S10,,S11,S13,S19,S27,S33, S34,S35 (11 students)	S2,S4,S7,S8,S12,S13,S17,S20,S21,S22,S23,S24,S26,27,S28,S29,S30,S32,S34 (18 students)	S2,S3,S7,S12,S20,S23,S25,S28,S30 (9 students)	S1,S3,S11,S18,S19,S25,S33,S35 (8 students)	S24,S26,S29,S31,S32 (5 students)	S14,S15,S31,S36 (4 students)	0
3.	S7,S26,S27, S30,S32 (5 students)	S1,S2,S3,S5,S6, S7,S8,S10,S11,S13,S14,S16,S17, S18,S31,S32,S33,S34 (18 students)	S1,S2,S3,S6,S16,S17,S19,S21,S22,S29,S31,S33 (12 students)	S4,S9,S12,S15,S19,S23,S25,S26,S30,S36 (10 students)	S4,S5,S10,S11,S18,S23,S34 (7 students)	S24 (1 student)	S8,S9,S12,S15,S20,S24,S25,S35 (8 students)	S20,S21,S22,S27,S28,S29 (6 students)	14,28,36 (3 students)	0
4.	S34 (1 student)	S2,S3,S8,S17,S19,S25,S28 (7 students)	S1,S2,S3,S4,S5S7,S8,S11,S12,S13,S14,S15,S16,S17,18,S19,S20,S21,S23,S24,S25, S26,S30,S35,S36 (25 students)	S1,S4,S5,S6,S7,S11,S12,S13,S14,S15,S16,S18,S20,S21,S22,S23,S24,S26,S27,S28,S29,S32,S34,S35,S36 (25 students)	S10,S22,S27,S28,S29,S31,S32 (7 students)	S9,S10,S31, S33 (4 students)	S6,S9,S33 (3 students)	0	0	0
5.	0	S1,S4,S5,S7,S11,S12,S16,S20,S23,S24,S25,S26,S	0	S2,S3,S6,S8,S9,S10,S13,S14,S15,S17,S19,S22,S32,S34 (14 students)	S5,S7,S8,S10,S13,S15,S16,S17,S18,S19,S20,S21, S23,S26,S27,S2	S18,S21,S33 (3 students)	S1,S2,S3,S4,S6, S11,S12,S24,S25,S30,S32,S35,S	S28,S29,S30 (3 students)	S9,S14,S22, S29,S33 (4 students)	0

		27,S31,S35,S36 (16 students)			8,S31,S34 (18 students)		36 (13 students)			
6.	0	S1,S3,S4,S5,S6, S7,S10,S11,S24, S25,S26,S27 (12 students)	S10 (1 student)	S2,S8,S9,S17,S18, S19,S21,S28,S29, S30,S31,S32,S33, S34,S35,S36 (16 students)	S1,S4,S5,S6,S7, S8,S11,S13,S14, S16,S18,S19,S2 0,S24,S25,S26,S 27,S28,S30,S32, S34 (21 students)	0	S2,S3,S9,S12,S1 5,S17,S21,S22,S 23,S29,S31,S33, S35,S36 (14 students)	S12,S13,S14 ,S15,S16,S2 0,S22,S23 (8 students)	0	0
7.	0	S5,S11,S13,S14, S16,S22(6 students)	S3,S9,S19,S21,S 24 (5 students)	S2,S8,S9,S12,S17, S18,S19,S20,S21, S23,S25,S27,S35 (13 students)	S5,S13,S15,S17, S22,S23,S25,S2 7,S29,S30,S33, S35,S36 (13 students)	S1,S3,S4,S6, S7,S10,S15, S19,S24,S28 (10 students)	S1,S2,S4,S6,S7, S8,S9,S11,S12,S 15,S17,S22,S23, S25,S27,S29, S30,S33,S35,S3 6 (20 students)	S26,S30,S31 ,S29,S32,S3 3,S34,S36 (8 students)	S4,S31 (2 students)	0
8.	0	S1,S3,S4,S5,S6, S7,S9,S11,S12,S 13,S14,S16,S20, S22,S23 (15 students)	S3,S18,S21 (3 students)	S2,S8,S10,S15,S1 7,S18,S21,S27,S2 9,S30 (10 students)	S1,S2,S4,S5,S7, S8,S10,S11,S12, S16,S20,S23,S2 4,S26,S27,S28,S 30,S31,S32,S33, S34,S36 (22 students)	S19,S26 (2 students)	S6,S9,S13,S17,S 19,S22,S25,S29, S35 (9 students)	S14,S15 (2 students)	S14,S15 (2 students)	0
9.	S13 (1 student)	S13,S17,S22,S2 5,S29,S30,S32,S 34,S35 (9 students)	S6,S9,S12,S15,S 20,S21,S23,S26, S30,S33,S34, S36 (12 students)	S5,S10,S11,S14, S16,S18,S19,S20, S21,S24,S26,S27, S36 (13 students)	S4,S5,S7,S8,S10 ,S14,S16,S18,S2 7,S28 (10 students)	S1,S3,S4,S7, S12,S15,S23 ,S28,S31,S3 3 (10 students)	S1,S2,S3,S11,S1 7,S19,S22,S24,S 25,S29,S32,S35 (12 students)	S2,S6,S8,S9 (4 students)	S31 (1 student)	0
10.	S7,S32,S34 (3 students)	S1,S2,S4,S6,S7, S8,S9,S11,S12,S 13,S14,S15,S17, S18,S21,S22,SS 23 (18 students)	S4,S5,S6,S13,S1 9,S20,S22,S26,S 28,S29,S30 (11 students)	S3,S10,S16,S24, S28,S33,S34 (7 students)	S10,S14,S15,S1 6,S17,S18,S31 (7 students)	S5,S19,S27, S30,S31,S35 (6 students)	S1,S2,S3,S8,S9, S11,S12,S21,S2 3,S24,S25,S27,S 33,S35,S36 (15 students)	S25,S26,S29 ,S32,S36 (5 students)	0	0

11.	S2 (1 student)	S1,S2,S4,S5,S6, S8,S9,S10,S11,S13,S15,S16,S18, S21,S22,S24,S25,S29 (18 students)	S3,S11,S16,S21, S28,S31 (6 students)	S3,S7,S12,S14,S17,S19,S20,S23,S26,S28,S30,S33,S34 (13 students)	S4,S5,S7,S10,S20,S22,S23,S24,S25,S26,S27,S34 (12 students)	S27 (1 student)	S1,S6,S8,S9,S12,S13,S15,S17,S19,S29,S30,S32,S33,S35,S36 (15 students)	S31,S32,S35,S36 (4 students)	S14 (1 student)	0
12.	0	S3,S19,S28,S30 (4 students)	S1,S2,S3,S5,S9, S12,S13,S15,S19,S20,S21,S23, S25 (13 students)	S4,S6,S9,S10,S12, S15,S20,S23,S25, S26,S27,S33,S21, S22,S24,S29,S31, S32,S34,S35,S36 (21 students)	S4,S8,S10,S17,S27,S32,S34, S26,S28,S29,S30,S31 (12 students)	S1,S2,S5,S7, S8,S11,S13, S14,S16,S17,S18,(11 students)	S6,S7,S11,S16,S18,S24,S33,S35, S36 (9 students)	0	S14 (1 students)	0
13.	S28 (1 student)	S1,S3,S23,S26,S28,S29,S34 (7 students)	S2,S3,S5,S8,S9, S10,S11,S12,S13,S15,S17,S19,S21,S22,S23,S24, S25,S27,S29,S31,S33,S34,S35 (23 students)	S2,S6,S8,S10,S12, S14,S17,S21,S25, S27,S30,S32,S33, S36,S19,S22,S24, S31,(18 students)	S4,S20,S26,S24, S25,S27,S29,S31 (8 students)	S5,S7,S9,S13,S16,S35 (6 students)	S1,S6,S7,S16,S18,S30,S32,S36 (8 students)	S4,S11,S15, S18,S20 (5 students)	S14 (1 student)	0
14.	0	S1,S2,S5,S6,S7, S10,S11,S13,S14,S16,S18,S19,S20,S22,S24,S25, S26,S31,S32 (19 students)	S1,S6,S15,S21,S22,S29,S34,S36 (8 students)	S3,S4,S8,S9,S12, S15,S17,S21,S23, S27,S28,S30,S34, S35,S36 (15 students)	S4,S5,S16,S18,S19,S20,S23,S24, S26,S28,S32 (11 students)	S29,S33 (2 students)	S2,S3,S7,S8,S10,S11,S12,S13,S17,S25,S27,S30,S31,S33,S35 (15 students)	0	S9,S14 (2 students)	0
15.	S28 (1 student)	S1,S5,S6,S10,S11,S26,S34,S35 (8 students)	S3,S9,S22,S29,S32,S34 (6 students)	S3,S4,S12,S15,S17,S19,S23,S24,S28,S30,S31,S32 (12 students)	S1,S4,S5,S8,S10,S15,S16,S17,S24,S26,S27 (11 students)	S2,S7,S8,S9, S14,S16,S20,S21,S27,S29, (10 students)	S2,S6,S7,S11,S12,S13,S18,S19,S20,S21,S23,S25, S30,S31,S33,S35,S36 (17 students)	S13,S18,S22,S25,S36 (5 students)	S14 (1 student)	0

16.	0	S3,S4,S7,S10,S11,S12,S14,S15,S17,S20,S22,S23,S26,S28,S34 (15 students)	S9,S10,S11,S12,S16,S22,S29,S36 (8 students)	S2,S6,S8,S9,S16,S18,S19,S21,S25,S27,S30,S31,S32,S35 (14 students)	S1,S4,S5,S7,S8,S14,S15,S19,S20,S23,S24,S26,S27,S28,S32,S34 (16 students)	S1,S5,S22,S29,S33,S36 (6 students)	S2,S3,S6,S13,S17,S18,S21,S25,S31,S34,S35 (11 students)	S13 (1 student)	S30 (1 student)	0
17.	S10, S13 (2 students)	S18,S19,S20,S34,S35 (5 students)	S1,S3,S4,S6,S7,S8,S9,S12,S18,S19,S21,S22,S23,S24,S27,S28,S29,S31,S35,S36 (20 students)	S1,S3,S4,S5,S8,S9,S10,S11,S12,S13,S14,S15,S16,S21,S22,S23,S24,S25,S27,S28,S30,S31,S32,S33 (24 students)	S5,S16,S26,S32,S34 (5 students)	S26,S29,S36 (3 students)	S2,S11,S15,S20,S25,S30,S33 (7 students)	S2,S6,S7,S17 (4 students)	S14,S17 (2 students)	0
18.	0	S2,S3,S4,S5,S13,S14,S15,S16,S17,S18,S19,S20,S21,S22,S34,S35,S36 (17 students)	S5,S6,S9,S10,S13,S21,S27,S31,S32,S34,S36 (11 students)	S1,S12,S23,S24,S25,S26,S27,S28,S29,S30,S31,S32,S33 (13 students)	S1,S3,S7,S8,S11,S12,S15,S16,S17,S19,S20,S22,S23,S24,S25,S28,S29,S30,S33,S35 (20 students)	S8 (1 student)	S2,S4,S18,S26 (4 students)	S6,S7,S9,S10,S11 (5 students)	S14 (1 student)	0

Since the main research problem was to determine whether or not students' misconceptions change towards scientific conceptions, the "Misconceptions (M)" category in Table 4 was detailed. Students' responses were further analyzed in term of unveiling their misconceptions based on the four-tier test (the EMCS) items of pre- and post-tests. These are presented in Table 5.

Table 5

Students' misconceptions about work and energy and their changes from pre-test to post-test

Sub-Concepts of work and energy	Students' Misconceptions	No	Pre-test		Post-test		Conceptual Changes	%
			Students' code	%	Students' code	%		
Work	The value of work is positive if it moves to the right or upward and negative if it moves left or down	3	S4,S5,S10, S11,S18,S23,S34 (7 Students)	19,4	S24 (1 Student)	2,7	Positive (+)	16,7
	It takes a large elevation angle value to produce the greatest of work	9	S4,S5,S7,S8,S10,S14, S16,S18,S27,S28 (10 Students)	27,7	S1,S3,S4,S7,S12,S15, S23,S28,S31,S33 (10 Students)	27,7	Positive (+)	0
	The slope of the trajectory affects the magnitude of the work done by the force of gravity	15	S1,S4,S5,S8,S10,S15, S16,S17,S24,S26,S27 (11 Students)	30,6	S2,S7,S8,S9,S14,S16, S20,S21,S27,S29,S34,S35 (10 Students)	27,8	Positive (+)	2,82
		12	S4,S8,S10, S17,S27,S32,S34,S26, S28,S29,S30,S31 (12 Students)	33,3	S1,S2,S5,S7,S8,S11,S13,S14,S16,S17,S18,(11 Students)	30,5	Positive (+)	2,8
Work of conservative and non-conservative force	The total work of a non-conservative force on a closed path is zero and does not engrave on the motion path of the object	1	S1,S2,S3,S4,S5,S6,S12,S18,S23, S26 (10 Students)	27,8	S32 (1 Student)	2,7	Positive (+)	25
		8	S1,S2,S4,S5,S7,S8,S10,S11,S12, S16,S20,S23,S24,S26, S27,S28,S30,S31,S32, S33,S34, S36 (22 Students)	61,1	S19,S26 (2 Students)	5,55	Positive (+)	55,5

Sub-Concepts of work and energy	Students' Misconceptions	No	Pre-test Students' code	Pre-test %	Post-test Students' code	Post-test %	Conceptual Changes	%
	The total work of the conservative force depends on the trajectory of the object	4	S10,S22,S27,S28,S29, S31,S32,(7 Students)	19,4	S9,S10,S31,S33 (4 Students)	11,1	Positive (+)	8,3
		14	S4,S5,S16, S18,S19,S20,S23, S24,S26,S28,S32 (11 Students)	30,5	S29,S33 (2 Students)	5,5	Positive (+)	24,9
Relation of potential energy, kinetic energy, and mechanical energy	The amount of kinetic energy is proportional to the resulting height	10	S10,S14,S15,S16,S17, S18,S31 (7 Students)	19,4	S5,S19,S27,S30,S31, S35 (6 Students)	16,7	Positive (+)	2,7
	In attempts by non-conservative forces, work by friction does not affect the kinetic energy and potential energy of a particle	11	S4,S5,S7,S10,S20,S22,S23, S24,S25,S26,S27,S34 (12 Students)	33,3	S27 (1 Student)	2,78	Positive (+)	30,5
		13	S4,S20,S26,S24,S25,S27,S29,S31 (8 Students)	22,2	S5,S7,S9,S13,S16,S35 (6 Students)	16,6	Positive (+)	5,6
		17	S1,S3,S7,S8,S11,S12, S15,S16,S17,S19,S20, S22,S23,S24,S25,S28, S29,S30,S33,S35 (20 Students)	55,5	S8 (1 Student)	2,7	Positive (+)	52,7
Conservation Law of mechanical energy	work of conservative forces on trajectories that have greater elevation angles	2	S2,S4,S7,S8,S12,S13, S17,S20,S21,S22,S23, S24,S26,27,S28,S29,S30,S32,S34 (18 Students)	50 %	S2,S3,S7,S12,S20,S23,S25, S28,S30 (9 Students)	25 %	Positive (+)	25 %
	If there is a law conservation of mechanical	6	S1,S4,S5,S6,S7,S8,S11,S13,S14,	58,3	0	0	Positive (+)	58,3

Sub-Concepts of work and energy	Students' Misconceptions	No	Pre-test Students' code	Pre-test %	Post-test Students' code	Post-test %	Conceptual Changes	%
	energy and there are two objects that have different mass, larger mass more quickly reach the ground, or objects whose lighter mass will be faster downward because of the greater acceleration		S16,S18,S19,S20,S24, S25,S26,S27,S28,S30, S32,S34 (21 Students)					
	The more difficult or longer a trajectory to go through work of conservative force the greater.	5	S5,S7,S8,S10,S13,S15,S16, S17,S18,S19,S20,S21, S23,S26,S27,S28,S31, S34 (18 Students)	50	S18,S21, S33 (3 Students)	8,3	Positive (+)	41,7
		7	S5,S13,S15,S17,S22,S23,S25,S27,S29,S30,S33,S35,S36 (13 Students)	36,1	S1,S3,S4,S6,S7,S10,S15,S19,S24,S28 (10 Students)	27,7	Positive (+)	8,32
		18	S1,S3,S7,S8,S11,S12, S15,S16,S17,S19,S20, S22,S23,S24, S25,S28,S29,S30,S33, S35 (20 Students)	55,5	S8 (1 Student)	2,78	Positive (+)	52,7
	Students consider the work made by conservative forces to be greater on	16	S1,S4,S5,S7,S8,S14,S15,S19,S20,S23,S24, S26,S27,S28,S32,S34	44,4	S1,S5,S2,S29,S33,S36 (6 Students)	16,7	Positive (+)	27,7

Sub-Concepts of work and energy	Students' Misconceptions	No	Pre-test Students' code	%	Post-test Students' code	%	Conceptual Changes	%
	steeper trajectories		(16 Students)					

As it can be seen from Table 5, most of the changes in students' misconceptions were positive. This means that the students changed their misconceptions towards scientific conceptions. The reduction of misconceptions is categorized based on the sub-concept of work and energy on the problem. For example, the law conservation of mechanical energy reduction misconception occurred significantly, that is with the largest percentage compared to another sub-concept. However, there are still some students who have misconceptions (e.g. S1, S5, and S8). It indicates that the student still holds his misconceptions after the treatment. This is in line with previous research, many studies on conceptual change (e.g. Samsudin et al., 2016; Lin, 2016; Shen, Liu, & Chang, 2017) found that conceptual change is an instance intense process because misconceptions are well fixed in students' previous brain schema.

Based on the data presented in Table 4, possible types of changes from pre-test and post-test were constructed and given the sample of students' responses (see Table 6).

Table 6

Possible types of changes in the criterion of students' responses based on Table 4

Change' Category	Pre-test		→	Post-test	Examples of students' conceptions	Students & Test Number
Acceptable (A)	1	M	→	PU	**S1 for no. 1: "**At the pre-test, S1 considered that The total work of a non-conservative force on a closed path is zero and does not engrave on the motion path of the object. After his understanding of the concept partially enhanced and when the post-test he response correctly on the first tier was the total work of a non-conservative force depend on track. Unfortunately, his response to the second tier is the total work of a non-conservative force has a value of mechanical energy is constant.	• S1, S5, S6, S12, S13, S23 for (No. 1) • S8, S27, S34, S35 for (No.2) • S4, S23 for (No.3) • S22, S27, S28, S29, S32 for (No.4) • S8, S10, S13, S15, S17, S19 for (No.5) • S8, S18, S19, S28, S30, S32, S34 for (No.6) • S8, S17, S18, S20, S23, S25 for (No.7) • S2, S8, S10, S27, S28, S30, S31, S32,S33, S34, S36 for (No.8) • S5, S10, S14, S16, S18, S23, S27, S33 for (No.9) • S10, S14, S16 for (No.10) • S7, S20, S23, S26, S34 for (No.11) • S4, S11, S26, S27, S29, S30, S31 for (No.12) • S24, S31 for (No.13) • S4, S23, S27, S28 for (No.14)

Change' Category		Pre-test	→	Post-test	Examples of students' conceptions	Students & Test Number
						• S4, S15, S17, S24 for (No.15) • S19, S27, S28 for (No.16) • S5, S16, S32, S36 for (No.17) • S1, S12, S23, S24, S25, S28, S29, S30, for (No.18)
	2	M	→	U	**S2 for no 1.** :"At the pre-test, S2 considered that The total work of a non-conservative force on a closed path is zero and does not engrave on the motion path of the object As a consequence, he chose the wrong answer for the first tier and second tiers and he chose "sure" for confidence rating. Afterward, his understanding of the work of non-conservative force concept completely, enhanced and when the post-test he chose correctly on the first and the second tiers was The total work of a non-conservative force depends on track and value of mechanical energy is constant.".	• S2, S3, S4, S14, S18, S26 for (No. 1) • S4, S17, S21, S22 for (No.2) • S5, S10, S11, S18, S34 for (No.3) • S5, S7, S16, S20, S23, S31 for (No.5) • S1, S4, S5, S6, S7, S11, S24, S25, S26, S27 for (No.6) • S5, S13 for (No.7) • S1, S4, S5, S7, S11, S12, S16, S20, S23 for (No.8) • S15, S17, S18 for (No.10) • S5, S10, S22, S24, S25 for (No.11) • S6, S28, S29 for (No.12) • S26 for (No.13) • S5, S16, S18, S19, S20, S24, S32 for (No.14) • S1, S5, S10, S26 for (No.15) • S4, S7, S14, S15, S20, S23, S26 for (No.16) • S34 for (No.17) • S3, S5, S15, S16, S17, S19, S20 for (No.18)
	3	NU	→	PU	**S9 for No. 3: "**In the pre-test, S4 totally did not understand the concept about the value of work is positive and negative. After the post-test, she held partial understanding and was able to respond to the correct answer in the first tier but the reason that was still incorrect".	• S15, S20, S24, S25 for (No. 1) • S11, S19, S33 for (No.2) • S9, S12, S25 for (No.3) • S6 for (No.4) • S2, S3, S6, S32 for (No.5) • S2, S3, S6, S9, S17, S21, S29, S31, S33, S35, S36 for (No.6) • S2, S8, S9, S12, S16, S22, S23, S27, S35 for (No.7) • S17, S22, S29, S35 for (No.8)

Change' Category		Pre-test	→	Post-test	Examples of students' conceptions	Students & Test Number
						• S11, S19, S22, S24, S35 for (No.9) • S3, S8, S11, S12, S24, S33 for (No.10) • S12, S17, S19, S33 for (No.11) • S24, S33, S35, S36 for (No.12) • S30, S32, S36 for (No.13) • S3, S8, S12, S17, S30, S35 for (No.14) • S3, S12, S19, S23, S30, S31, S32, S34, S35, S36 for (No.15) • S2, S6, S18, S21, S25, S31, S32 for (No.16) • S11, S15, S25, S30, S33, for (No.17) • S26 for (No.18)
	4	NU	→	U	**S18 for No. 2**: "During the pre-test, S18 thought that work of conservative forces on trajectories that have greater elevation angles, while the post-test, S18 realized to change her thinking about work of conservative forces on trajectories that have smaller elevation angles"	• S8, S9, S17, S19, S21, S27 for (No.1) • S1, S18 for (No.2) • S8, S35 for (No.3) • S1, S4, S11, S24, S25, S26, S27, S29, S35, S36 for (No.5) • S3, S11 for (No.7) • S6, S9, S13 for (No.8) • S17, S25, S29, S32 for (No.9) • S1, S2, S9, S21 for (No.10) • S1, S6, S8, S9, S13, S15, S29, S30 for (No.11) • S1 for (No.13) • S2, S7, S10, S11, S13, S25, S26, S31 for (No.14) • S6, S11 for (No.15) • S3, S17 for (No.16) • S20, for (No.17) • S2, S4, S18 for (No.18)
	5	PU	→	U	**S3 for no. 13**: "During the pre-test, S3 response the correct answer on the first tier and his reason that were not correct on the second tier of the concept about non-conservative forces, work by friction does not affect the kinetic	• S7, S28, S36 for (No.1) • S5, S16 for (No.2) • S1, S2, S3, S6, S13, S16, S17, S31, S33 for (No.3) • S2, S3, S8, S17, S19, S25 for (No.4) • S10 for (No.6) • S3 for (No.8) • S29, S30, S34 for (No.9)

Change' Category	Pre-test	→	Post-test	Examples of students' conceptions	Students & Test Number
				energy and potential energy of a particle surprisingly, while the post-test S2 chose a correct answer in the first and the second tier with the confidence rating was sure. It is indicated that his understanding enhances from partially to totally understanding about non-conservative forces, work by friction affects the kinetic energy and potential energy of a particle surprisingly.	• S4, S6, S13, S22 for (No.10) • S11, S16, S21 for (No.11) • S3, S19 for (No.12) • S3, S23, S29, S34 for (No.13) • S1, S6, S22 for (No.14) • S10, S11, S12, S22 for (No.16) • S1, S13, S18, S19, S35, for (No.17) • S34, S35, S36 for (No.18)
Not Acceptable (NA)	1 M	→	NU	**S7 for no. 18** :" During the pre-test, S3 response The more difficult or longer a trajectory to go through work of conservative force the greater and she chose wrong reason referred to the first tier, but she chose "sure" in the third tier. It means that she did not understand the concept in the pre-test. Afterward, in the post-test she began to feel very confident when answer to the first and second tiers were incorrect. She changed confidence rating from "sure" to "not sure", consequently she held negative change from misconception to not understanding".	• S26, S29, S32 for (No. 2) • S28 for (No.5) • S13, S14, S16, S20 for (No.6) • S29, S34, S36 for (No.7) • S24 for (No.8) • S8 for (No.9) • S4, S20 for (No.13) • S7, S11, for (No.18)
	2 NU	→	M	**S4 for no. 7**: "During the pre-test, S4 assumed that the concept about The more difficult or longer a trajectory to go through work of conservative force the greater and she chose wrong reason referred to the first tier, but she chose "not sure" in the third tier.	• S3, S24, S25, for (No. 2) • S24 for (No.3) • S9, S33 for (No.4) • S1, S4, S6, S7, S10 for (no.7) • S19 for (No.8) • S1, S3 for (No.9) • S23, S27, S35 for (No.10) • S27 for (No.11) • S7, S16, S18 for (No.12)

Change' Category	Pre-test	→	Post-test	Examples of students' conceptions	Students & Test Number
				It means that she did not understand the concept in the pre-test. Afterward, in the post-test, she began to feel very confident when in answer to the first and second tiers were incorrect. She changed confidence rating from "not sure" to "sure", consequently she held negative change from no understanding to misconception".	• S5, S7, S16 for (No.13) • S33 for (No.14) • S2, S7, S20, S21 for (No.15) • S1 for (No.16) • S1 for (No.17)
3	PU	→	M	**S8 for no. 16**: "During the pre-test, S8 assumed that the concept about work made by conservative forces to be greater on steeper trajectories and she chose right reason referred to the first tier, but she chose "not sure" in the third tier. It means that she did partially understand the concept in the pre-test. Afterward, in the post-test she began to feel very confident when in answer to the first and second tiers were incorrect. She confidence rating from "not sure" consequently she held negative change from partial understanding to misconception".	• S32 for (No.1) • S13 for (No.2) • S34 for (No.5) • S3, S19, S24 for (No.7) • S12, S15, for (No.9) • S5, S19, S30 for (No.11) • S1, S2, S5, S13 for (No.12) • S9, S13, S25, S35 for (No.13) • S29 for (No.14) • S9 for (No.15) • S8, S36 for (No.16) • S29 for (No.17)
4	PU	→	NU	**S26 for no. 10**: "During the pre-test, S5 has chosen tier-one correct answer, the reason was not appropriate and the confidence rating was chosen "sure" about the amount of kinetic energy is proportional to the resulting height, It means that he had partial understanding in the pre-	• S29, S33, S34 for (No.1) • S15, S21, S22, S29, for (No.3) • S6, S9 for (No.9) • S26, S29, S32 for (No.10) • S31 for (No.11) • S11, S15 for (No.13) • S22 for (No.15) • S29, S35 for (No.16) • S6, S7, for (No.17) • S6, S9, S10 for (No.18)

Change' Category		Pre-test	→	Post-test	Examples of students' conceptions	Students & Test Number
					test. Unfortunately, in the post-test, he changed his answers for the second tier from the correct reason to incorrect reason based on the first tier's answer. Afterward, he chose the confidence rating "not sure".	
	5	U	→	PU	**S4 for no. 11**: "During the pre-test, S5 has chosen the correct answers in the first and second tiers and he chose the confidence rating "sure". It means that he held understanding the concept on non-conservative forces, work by friction affects the kinetic energy and potential energy of a particle. Unfortunately, in the post-test, he hesitated and changed his confidence rating from "sure" to "not sure". As consequence, he held negative change from understanding the concept to partial understanding".	• S10 for (No. 2) • S26, S30, for (No. 3) • S34 for (No.4) • S34, S27 for (No.3) • S4 for (No.11) • S10, S13, for (No.17)
No Change (NC)	1	PU	→	PU	**S20 for no. 9**: "During the pre-test until post-test, S20 response confidence rating "not sure" although she answered in the first and second tiers were correct about a small elevation angle value to produce the greatest of work , so she did not change her understanding. For this case, no change process sound "moderate understanding" because she still held partial understanding and she has the potency to enhance her knowledge"	• S10, S11, S16, S22, for (No. 1) • S6, S9 for (No.2) • S19 for (No.3) • S1, S4, S5, S7, S11, S12, S13, S14, S15, S16, S18, S20, S21, S23, S24, S26, S30, S35,S36 for (No.4) • S21 for (No.7) • S18, S21 for (No.8) • S20, S21, S26, S36 for (No.9) • S7, S20, S28 for (No.10) • S3, S27, S28 for (No.11) • S9, S12, S15, S20, S21, S23, S25 for (No.12) • S2, S8, S10, S12, S17, S19, S21, S22, S27, S33 for (No.13)

Change' Category		Pre-test	→	Post-test	Examples of students' conceptions	Students & Test Number
						• S15, S21, S34, S36 for (No.14) • S9, S16 for (No.16) • S3, S4, S8, S12, S21, S22, S23, S24, S31 for (No.17) • S27, S31, S32, S33, for (No.18)
	2	NU	→	NU	S12 for no.6: "On the concept about the law-conservation of mechanical energy and there are two objects that have different mass, larger mass more quickly reach the ground, or objects whose lighter mass will be faster downward because of the greater acceleration, S12 did not change her conception because she did not understand from pre-test until post-test. This case sounded "no understanding". She chose incorrect answers for first and second tiers and response "not sure" the concept for the third tier."	• S35 for (No.1) • S20 for (No.3) • S12, S30 for (No.5) • S12, S15, S22, S23 for (No.6) • S26, S30, S32, S33 for (No.7) • S25 for (No.8) • S2 for (No.9) • S25, S36 for (No.10) • S32, S35, S36 for (No.11) • S18 for (No.13) • S13, S18, S25 for (No.15) • S13 for (No.16) • S9, S27, S28, for (No.17)
	3	M	→	M	**S4 for no. 9**: "During the pre-test until post-test, S4 held misconception about a large elevation angle value to produce the greatest of work. The treatment could not change his misconception about this concept."	• S2, S7, S12, S20, S23, S28, S30, for (No. 2) • S10, S31 for (No.4) • S18, S21 for (No.5) • S15, S28 for (No.7) • S26 for (No.8) • S4, S7, S28 for (No.9) • S31 for (No.10) • S8, S17 for (No.12) • S16, S27 for (No.15) • S5 for (No.16) • S8 for (No.18)
	4	U	→	U	**S7 for no. 3:** "The S7 held good understanding of the concept about the value of work is positive if it forces in the same direction with displacement and negative if it forces in a different direction with displacement. She chose	• S7, S32, for (No.3) • S13 for (No.9) • S2 for (No.11)

Change' Category	Pre-test → Post-test		Examples of students' conceptions	Students & Test Number
			the correct answers for the first and second tiers and never changed her response for confidence rating "sure".	

The changing processes were separated into three categories to facilitate researchers in analyzing conceptual change that occurred in the students' thinking. As can be seen from Table 6, four types of possible changes were observed in each change category (A, NA, and NC). In the "A" category, students' understanding of "work and energy" changed from pre-test to post-test with some development. Students' understanding improved as a result of the PDEODE*E Tasks with the Think-Pair-Share model. Interestingly, in the "A" category, while students' responses in the misconception (M) criterion changed as a partial understanding category, they did not change as understanding (U) criterion. This means that misconceptions are opposed to change, and that conceptual change is time overwhelming process as given in excess of earlier researchers (e.g. Belge Can & Boz, 2016; Samsudin et al., 2016; Zvoch, Holveck, & Porter, 2019).

Conclusion and Recommendation

The main purpose of this study was to reconstruct the students' conceptions from the misconceptions condition towards scientific conceptions of work and energy through the PDEODE*E tasks with the Think-Pair-Share model. Results showed that the PDEODE*E tasks with the Think-Pair-Share model were an effective means of changing misconceptions students detained. Data presented in the tables clearly showed that after learning the PDEODE*E tasks with the Think-Pair-Share model, students improved their understanding. However, a few misconceptions motionless occurred in students' mind about work and energy occurred in the pre- and post-test. This possibly happened for some reason such level of students' significance (personal motivation aspect) was involved in PDEODE*E tasks. This case was imaginable because students' misconceptions were intensely entrenched into their existing knowledge structures. Hence, misconceptions were confirmed to be highly opposed to change, in other words, they were most vigorous (Lombardi, Sinatra, & Nussbaum, 2013; Mason et al., 2019; Zvoch, Holveck, & Porter, 2019).

To sum up, this research proved that the PDEODE*E tasks with the Think-Pair-Share model were effective in changing students' misconceptions and enhancing students' conceptual understanding. Moreover, the PDEODE*E tasks with the Think-Pair-Share model indicated that it is possible to change the traditional classroom setting in terms of easiness conceptual change. However, many diverse factors such as cognitive, motivational, ontological, and epistemological affected the conceptual change process (Lee & Byun, 2012; Lee & Yi, 2013)

Lastly, we suggest here that the success of the students was mostly arisen from the fact that the PDEODE*E tasks with the Think-Pair-Share model helped them to evaluate their previous knowledge, re-checked their ideas within their groups or whole-class discussions, and construct new concept in their minds especially by using exploration sheet. This was known as the conceptual change model planned by Posner, Strike, Hewson, and Gertzog (1982). Hence, we suggest that the PDEODE*E tasks with the Think-Pair-Share model should be used to reconstruct the students' conceptions from the misconceptions condition to scientific conceptions of work and energy.

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